An Integrated Process for Utilization of Pomegranate Peels

K. Kaderides, A. M. Goula, K. G. Adamopoulos

Laboratory of Food Processing and Engineering , Department of Food Science and Technology, School of Agriculture, Faculty of Agriculture, Forestry and Natural Environment, Aristotle University of Thessaloniki, Thessaloniki, Greece

Pomegranate Structure

24% Peel

14% Seeds

62% Juice

Composition of Pomegranate Peel Powder

Component	Content (%, dry matter)
Total solid	96.00
Moisture	4.00
Total sugar	31.38
Protein	8.72
Crude Fiber	21.06
Fat	9.40
Ash	5.00
Total phenolic	8.10

Aguilar et al.,2008; Ullah et al.,2012

Polyphenol Content of Pomegranate Peel Powder

Phenolic Fraction	Content (mg/100g dry matter)
Ellagic acid	44.19
Catechins	868.40
Gallic acid	125.80
Protocatechol	4.17
Parahydroxy benzoic acid	9.02
Vanilline	3.91
Caffeic acid	60.46
Ferulic acid	5.89
P-coumaric acid	17.64
Others	8.20

Rowayshed et al., 2013

Pomegranate: Biological Activities

- Antioxidant activity
- Anticancer properties
- Reduce risk of coronary heart disease
- Antimicrobial activity
- Antifungal activity

Exploitation of Pomegranate By-products

Pomegranate

Seeds

Peel

Fodder

Cosmetics

Food Industry

Fodder

Pharmaceutical

Project Objective

The exploitation of pomegranate peel based on:

1. *Ultrasound – assisted extraction*
2. *Encapsulation by spray drying*

- **Optimization**:

1. *Ultrasound – assisted extraction of phenolic compounds*
2. *Encapsulation by spray drying of phenolic compounds*

- **Incorporation of encapsulated phenolic compounds in foods** (hazelnut paste) aiming to delay the oxidation

Techniques of Extraction Phenolic Compounds From Pomegranate Peel

Technique of extraction	Time (min)	Yield (g GAE/100 g dry matter)	Reference
Normal Stirring	60	8.26 – 11.9	Wang et al., 2011; Pan et al., 2011
Pressurized liquid	15	25.8 – 26.4	Cam & Hisil, 2010
Ultrasound-assisted			Pan et al., 2011
(Continuous)	6	14.8	
(Pulsed)	8	14.5	
Microwave-assisted	1	21.5	Zheng et al., 2011

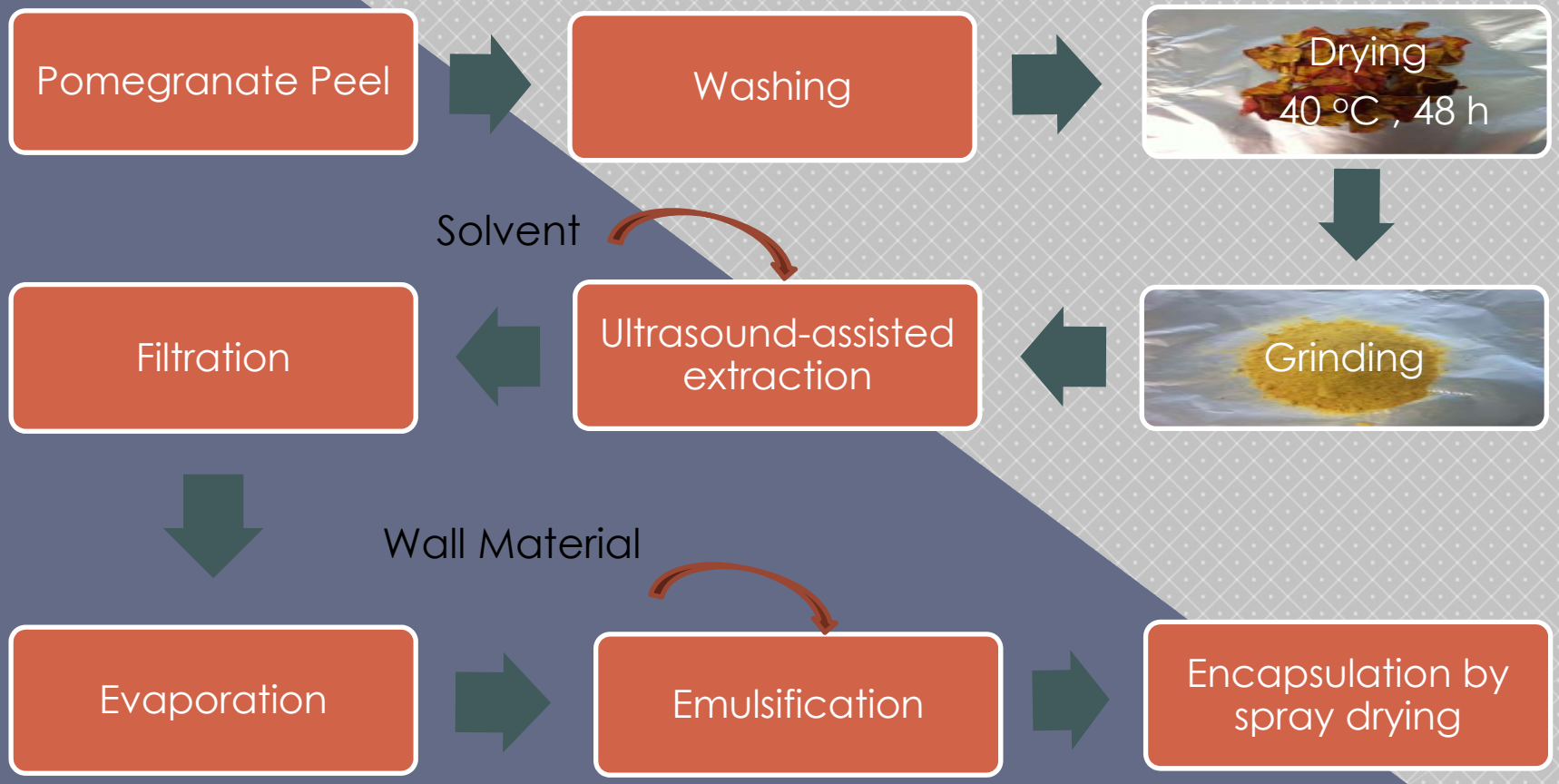
Why Encapsulation of Phenolic Compounds

- Increase their stability during storage and their passage through the gastrointestinal tract
- The improvement of color
- The masking of astringency
- Suitability for use as an additive in functional foods

Fang & Bhandari, 2010

Materials and Methods

Integrated Process for Pomegranate Peel Application in Food Industries



Factors Affecting the Ultrasound-Assisted Extraction Process

1. Extraction temperature
2. Solvent type
3. Solvent/Solid ratio
4. Amplitude level
5. Pulse duration/Pulse interval ratio
6. Extraction time

130 W, 20 kHz VCX-130 Sonics and Materials (Danbury, CT, USA) με Ti–Al–V probe (13 mm)

Experimental Design for Optimization of Ultrasound-Assisted Extraction of Phenolic Compounds from Pomegranate Peel

- Response surface methodology (32 experiments)

Parameters	Levels				
	1	2	3	4	5
Solvent type	Ethanol	Methanol	Water	50% Aqueous methanol	Ethyl-acetate
Extraction temperature (T, °C)	25	30	35	40	45
Solvent/Peel ratio (LP)	10/1	20/1	30/1	40/1	50/1
Amplitude level (A, %)	20	30	40	50	60
Pulse duration/pulse interval ratio (on/off) (PUL, -)	5/15	3/4	7/6	19/12	2/1

Factors Affecting the Spray Drying Encapsulation Process

1. *Inlet air temperature*
2. *Feed solids concentration*
3. *Ratio of core to wall material*
4. *Drying air flow rate*
5. *Drying air humidity*

Buchi, B-191,
Buchi Laboratoriums-Technik,
Flawil, Switzerland

Experimental Design for Optimization of Spray Drying Encapsulation of Phenolic Compounds from Pomegranate Peel

- Response surface methodology (32 experiments)

Parameter	Levels				
	1	2	3	4	5
Wall material (Wm)	MD	SMP	MD/SMP	MD/WPI	MD/GA
Ratio of core to wall material (c/w)	1/9	1/5.3	1/3.7	1/2.9	1/2.3
Inlet air temperature (Ti, °C)	150	160	170	180	190
Drying air flow rate (Qa, %)	50	54	58	62	66
Feed solids concentration (S, %)	10	15	20	25	30

MD: Maltodextrin
SMP: Skim Milk Powder
WPI: Whey Protein Isolate
GA: Gum Arabic

Physical properties of the Microcapsules

Moisture content

Bulk density

Rehydration ability

Incorporation of phenolic compounds in foods

PRODUCT: Hazelnut paste

AGENT ADDED: Phenolic extract encapsulated in optimal conditions

PHENOL CONCENTRATION: 5000 ppm

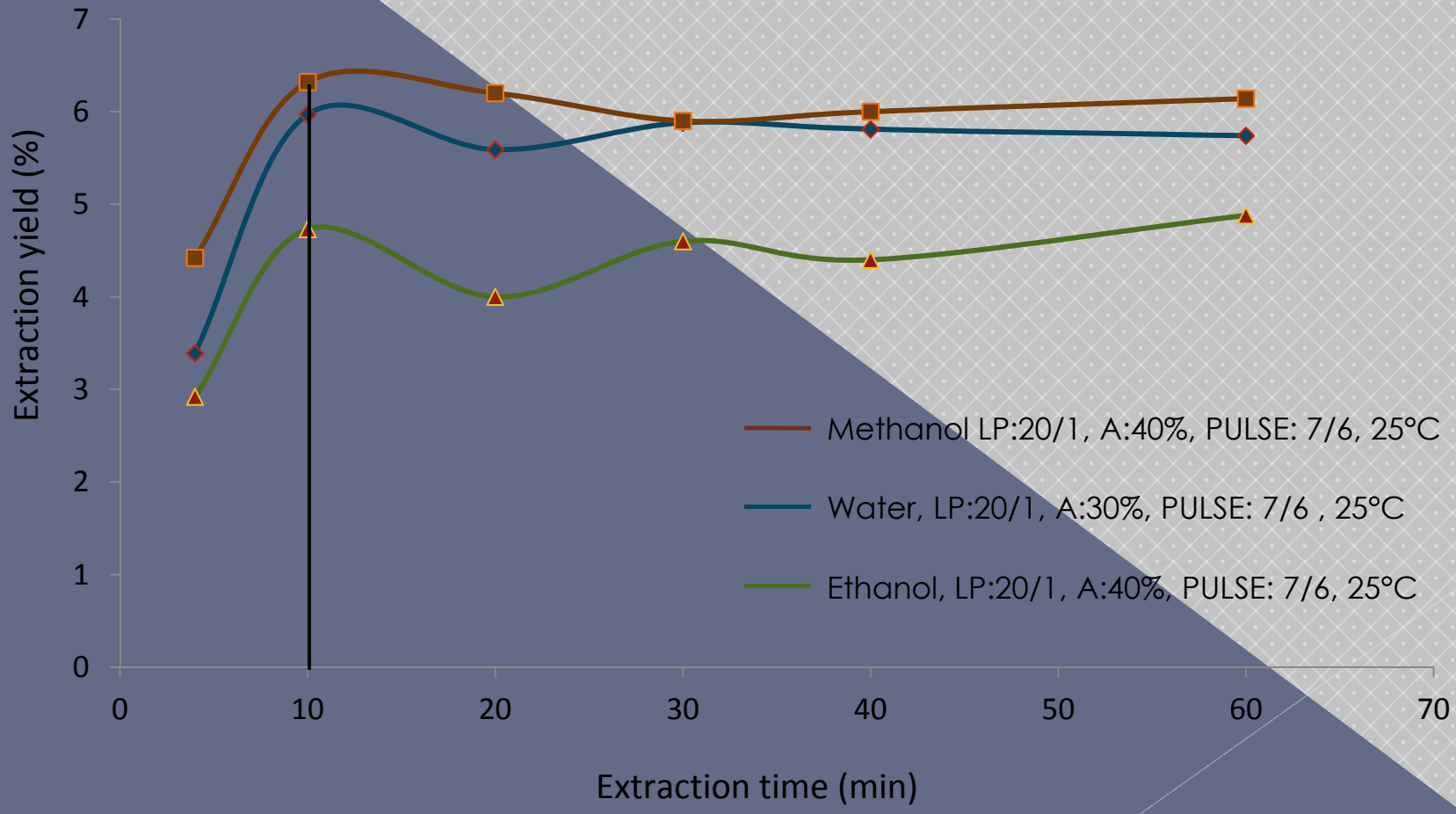
Oxidation rate in 3 samples of hazelnut paste was tested:

1. Addition of nanoencapsulated extract
2. Addition of crude extract
3. Control sample

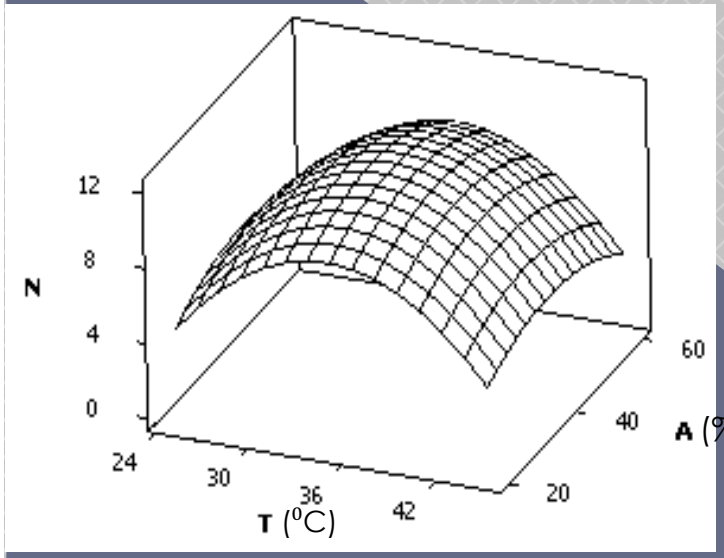
An accelerated shelf-life test at 60 °C was carried out until 51 days

Results

Extraction Yield – Effect of Extraction Time



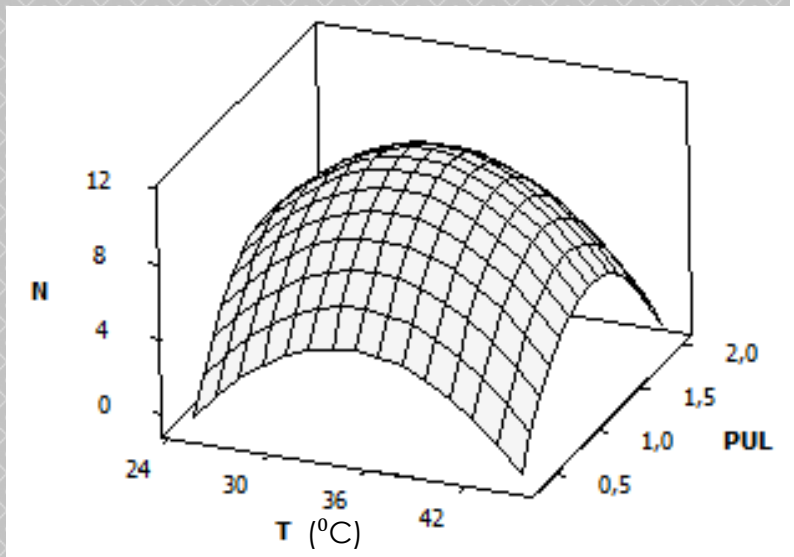
Extraction Yield - Effects of Various Parameters

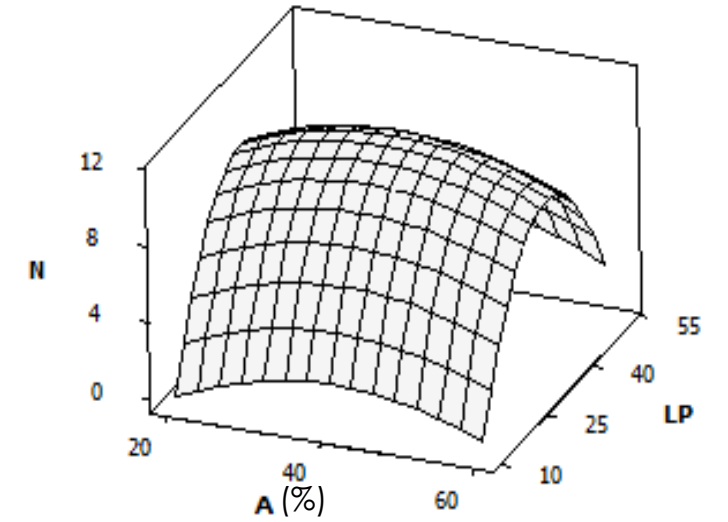


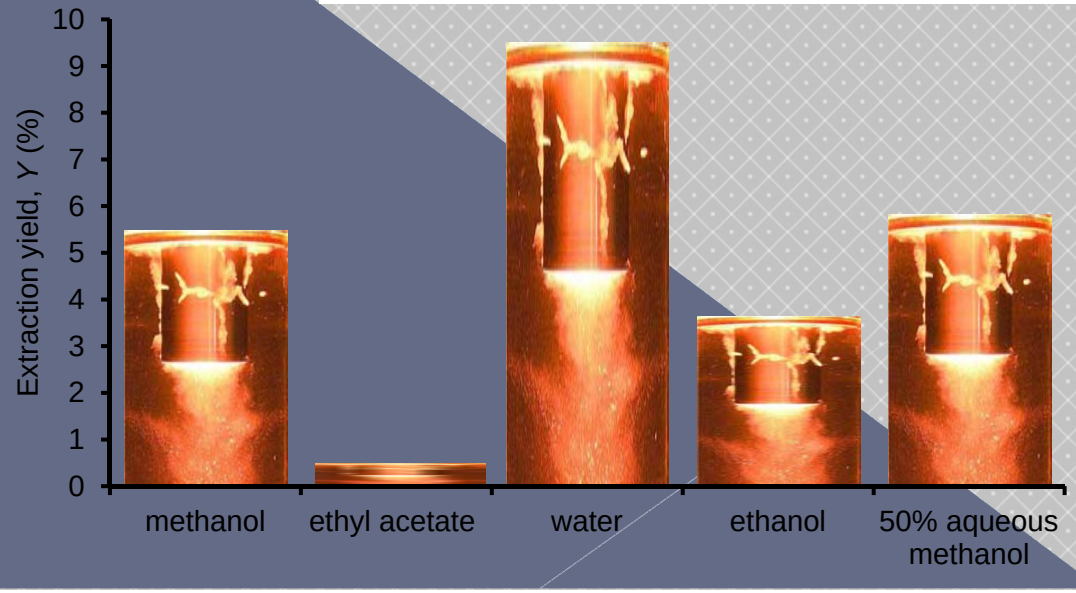
*N: g GAE/100 g

N_{max} →

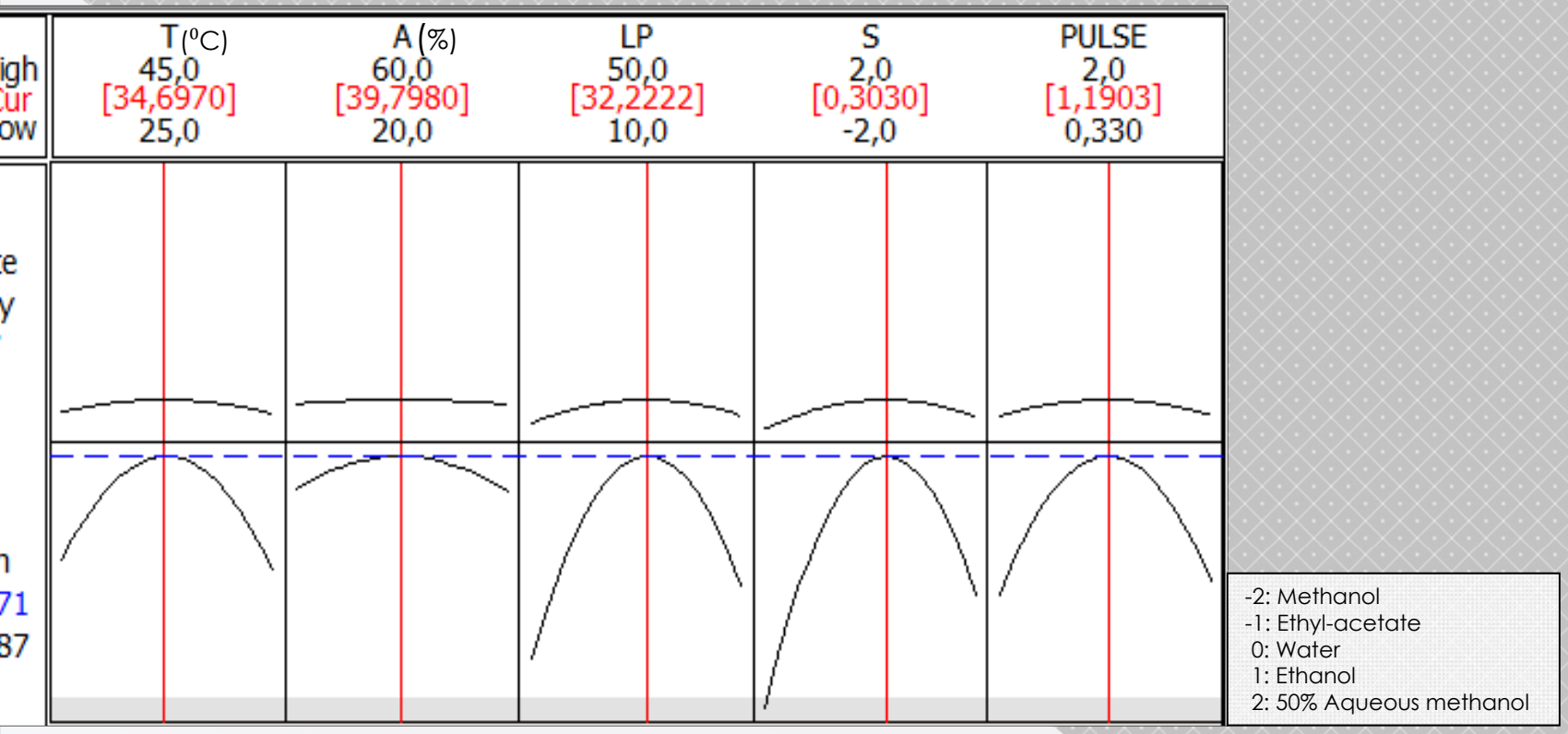
T: 35°C
A: 40%
PUL: 1.2
LP: 35/1
S: Water







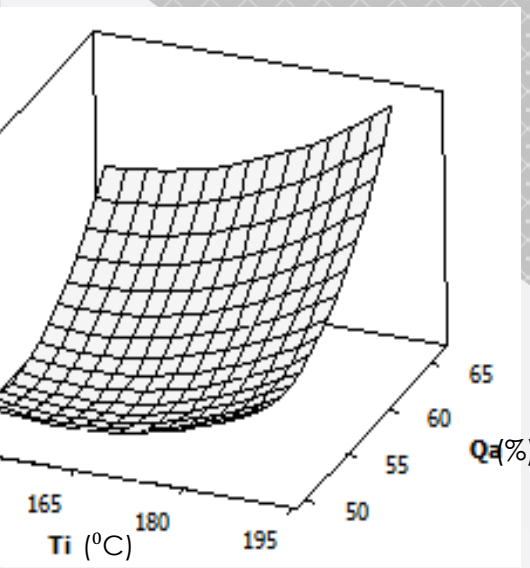
Extraction Yield – Optimization



Empirical model of extraction yield:

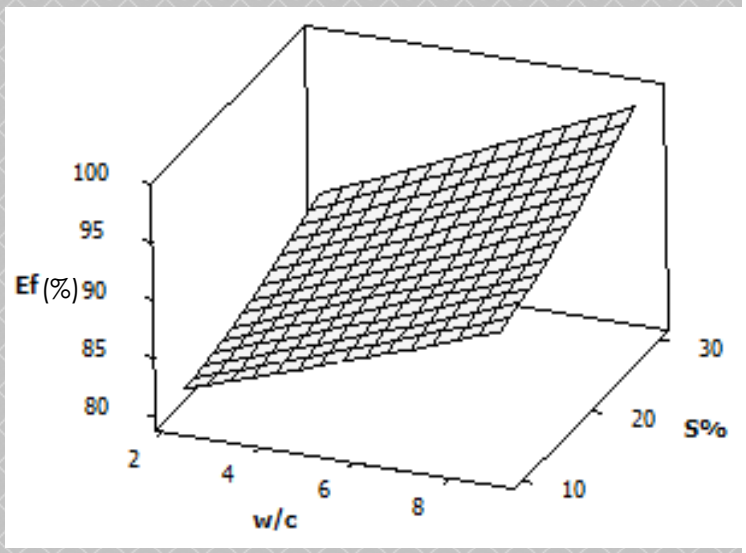
$$Y = -88{,}058 + 3{,}417 \times T + 1{,}197 \times LP + 21{,}161 \times PULSE - 0{,}048 \times T^2 - 0{,}018$$

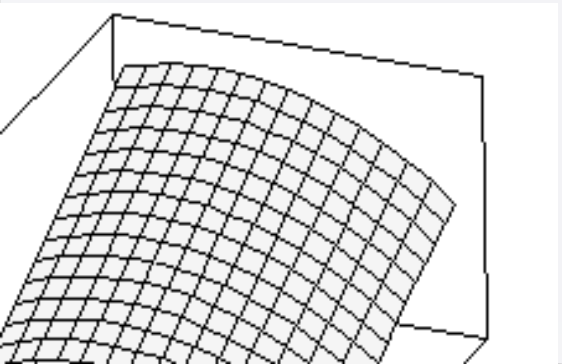
capsulation Efficiency- Effects of Various Parameters

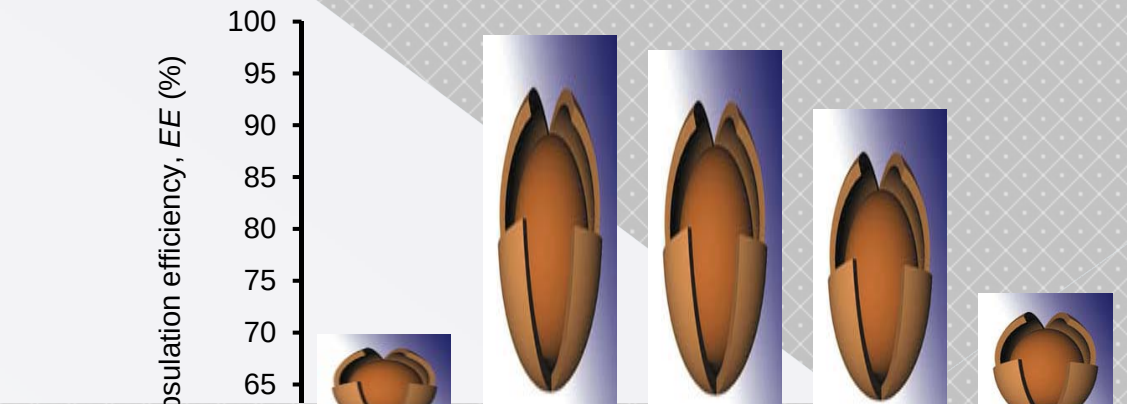


↑Ef →

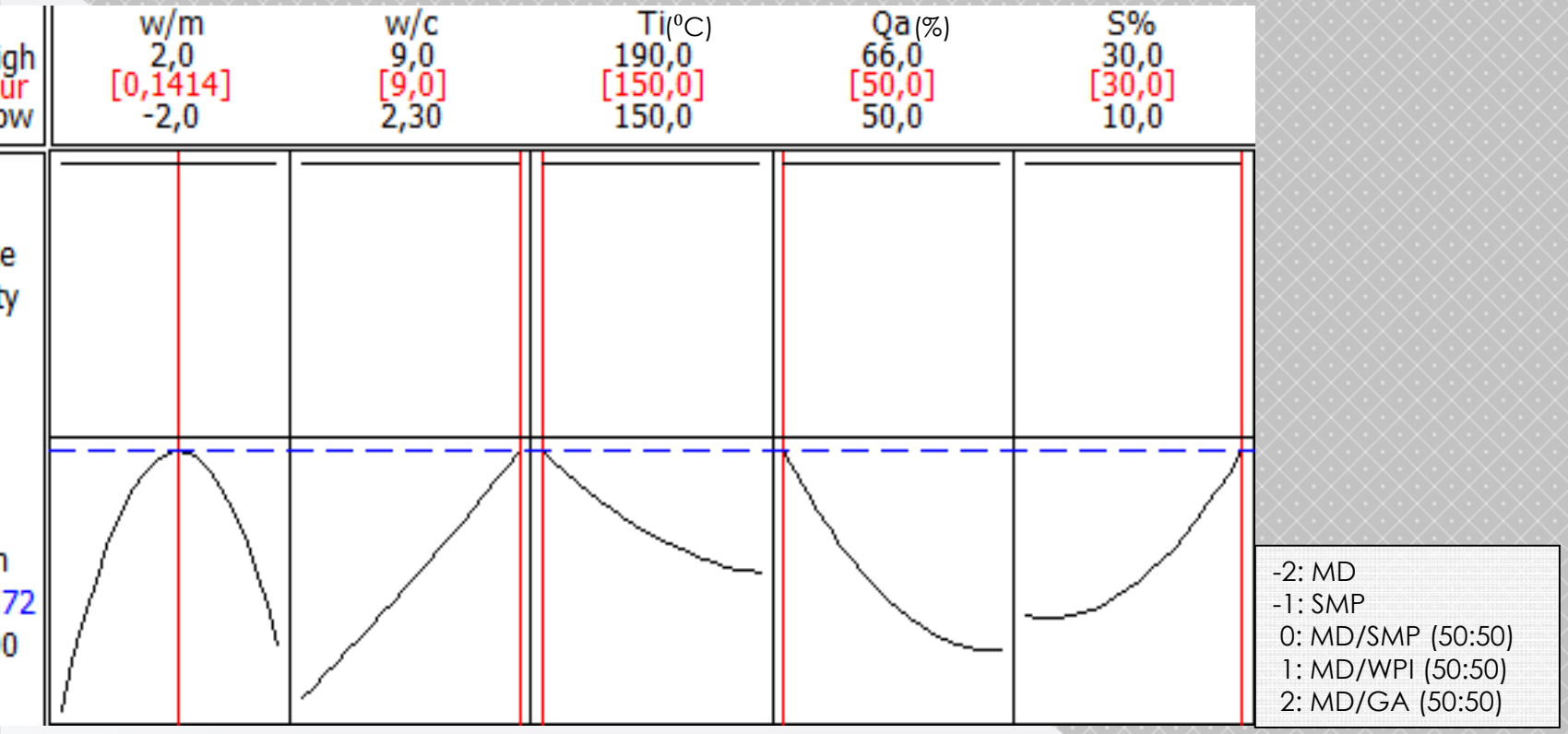
- Ti ↑
- Qa ↑
- S ↑
- w/c ↑
- Efmax:
- MD/WPI







ncapsulation Efficiency – Optimization



Empirical model of encapsulation efficiency:

$$Ef = 592.196-10.348 \cdot Qa-0.613 \cdot S-5.510 \cdot Wm\,\hat{}\,2+0.081 \cdot Qa\,\hat{}\,2+0.050 \cdot S\,\hat{}\,2+0.181 \cdot Wm \cdot S-$$

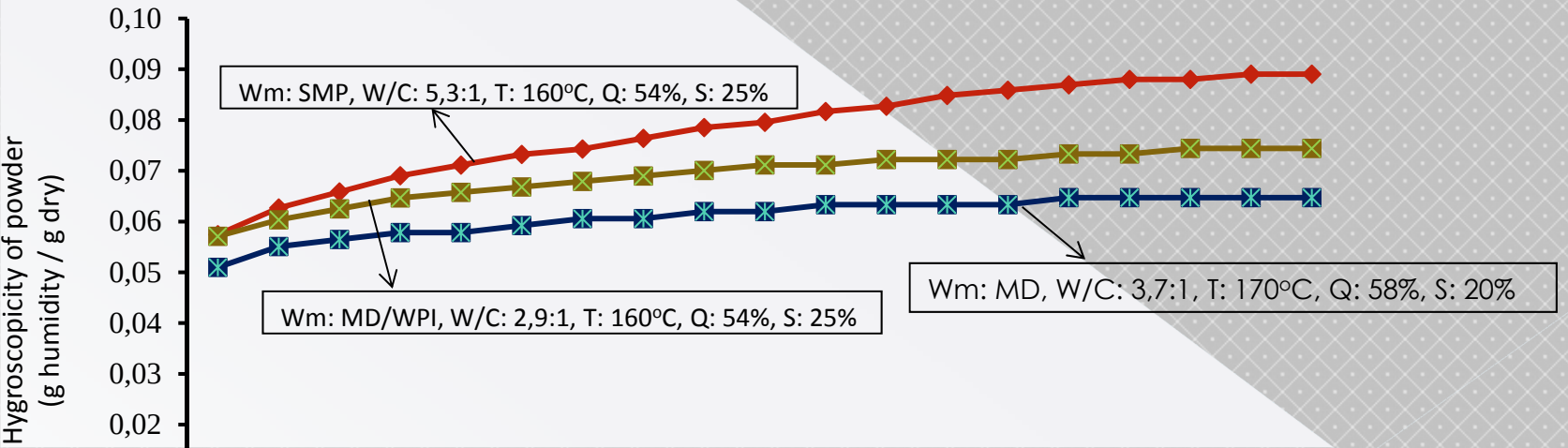
hysical properties of the Microcapsules

Powder moisture content: 3.79 to 6.02%

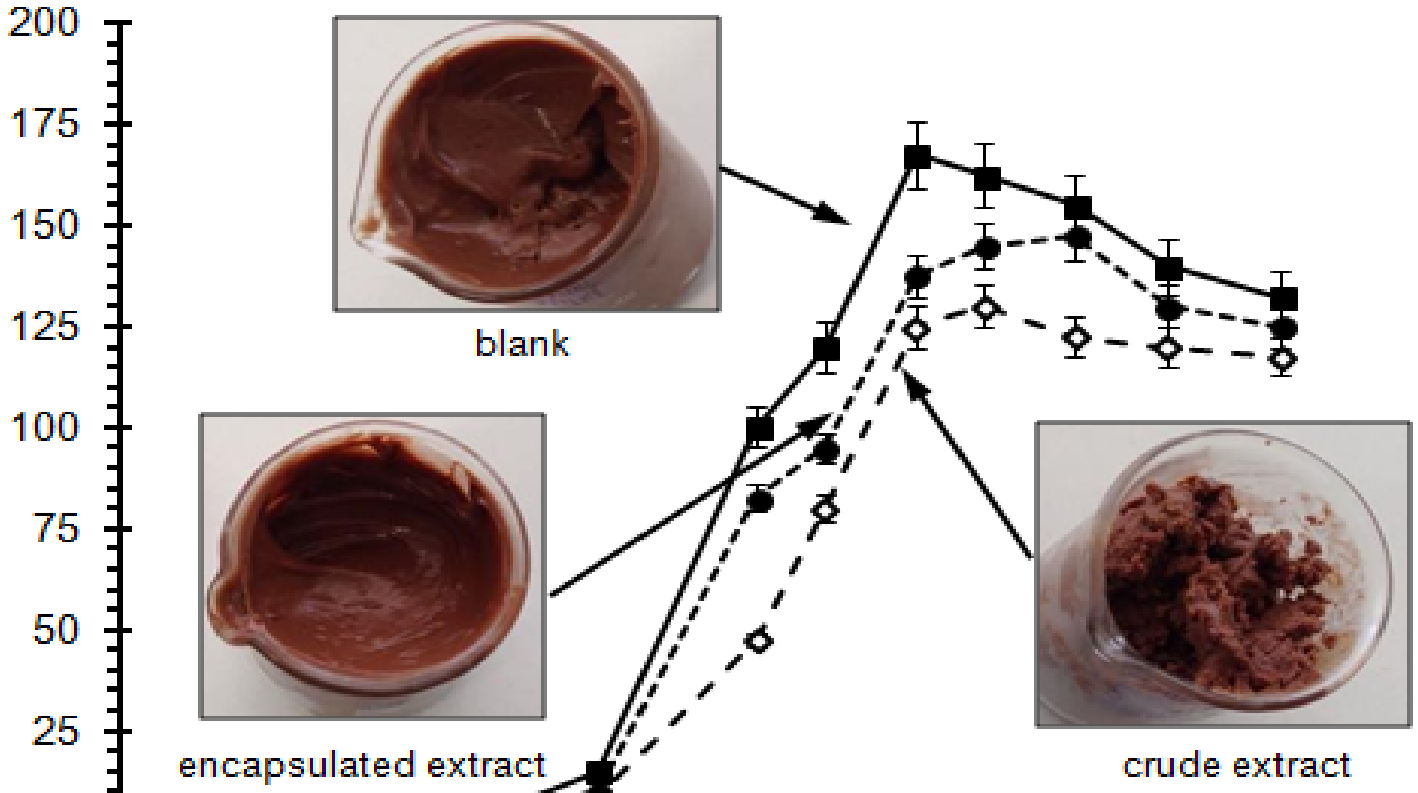
Bulk density: 0.13 to 0.74 g/mL

Rehydration: 19-48 s

Hygroscopicity:



ect of Pomegranate Peel Extract (Crude and Encapsulated) on Oxidative Deterioration of Hazelnut Paste



Conclusions

Conclusions

egrated approach for utilization of pomegranate peels is suggested based on
und-assisted extraction of phenolic compounds followed by its encapsulation
using a suitable spray drying technique

asounds increased extraction yield, but mainly shortened the treatment time by
r 20 times.

action yield increased increasing extraction temperature up to 35°C, amplitude
l up to 40%, solvent/peels ratio up to 33/1, decreasing pulse duration/pulse
rval ratio and using solvent type water.

highest encapsulation efficiency achieved about 98.64% using
todextrin/whey protein isolate as wall material.

iency increased with an increase in inlet air temperature, drying air flow rate,
d solids concentration, and wall to core material ratio.

Thank you